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CONFERENCES AND SEMINARS IN CONJUNCTION WITH THE ITHACA MEETING OF THE S. P. E. E., JUNE 19, 20 AND 21, 1934

Through its Summer Schools of the past seven years the S. P. E. E. has brought together groups of engineering teachers from the major divisions of the curriculum, together with industrial and educational specialists, with a view to the betterment of teaching. The programs have combined a broad survey of content, sources and correlations of subjects, with intensive study of learning processes and teaching methods. The project received wide recognition and its results have been most fruitful.

During the present year a representative committee of the Society, headed by Past-president Seaton, is making a careful study and appraisal of the Summer School project, preparatory to recommending a future plan of action. Pending the committee's report, it has seemed impracticable to plan for a separate session of the Summer School in 1934, but a favorable time to try an experiment of somewhat different character and one within the Society's own resources.

This experiment is to consist of a group of seminars or conferences as a prelude to the annual meeting of the Society at Ithaca. Each seminar will cover a period of two and one half days, and will deal with some newly developing subject of engineering teaching and research or phase of college administration. The time set apart for this purpose extends from Tuesday morning, June 19, to noon of the following Thursday.

The aim of each seminar or conference will be to bring together a group of our younger men who are doing pioneer work over the country for a pooling of experience and for mutual guidance and stimulation. The Program Committee will endeavor to organize as many such seminars as can be set up on a self-directing basis. Each seminar will be planned and conducted by a committee of men actively engaged in its field. These committees will consist for the most part of younger men, many of them associate and assistant professors, who will find their incentives in a broader acquaintance and recognition and in the direct value of the materials produced and discussed.

The nucleus of each committee, whenever practicable, will consist of a chairman and a secretary who are already acquainted with each other and often in neighboring institutions, and a local representative in the Cornell faculty who will be responsible for service

arrangements. In some cases the committee will work as a unit, in which case a total membership of from 5 to 7 will suffice. In other cases a small group will work on the program and a larger group of regional representatives will work on the promotion of attendance.

The seminars as now projected will be of two or three types. Probably the largest number will be concerned with fairly definite technical subjects such as "Electronics and Electrical Communications," "Laboratory Uses of Models in Structures and Hydraulics," "Fluid Mechanics," etc. A second group is proposed in departmental problems for teachers of English, drawing, mathematics, etc. The third relates to administrative problems, such as "Pre-College Guidance and Freshman Orientation," and major curriculum changes.

The program suggested for each seminar on a technical or content topic includes, as may be appropriate:

1. A resume and critical evaluation of source material.
2. A consideration of its place and relations in the curriculum.
3. The organization of subject matter for teaching.
4. Laboratory equipment and procedures.
5. Research possibilities for college laboratories.
6. Preparation of teachers.
7. Industrial contacts and collaboration.

It is hoped that the program, instead of producing only expressions of opinion and personal experience, may be built up by apportioning important topics to individuals who will work them up thoroughly and so contribute materials of wide value to their colleagues; in short, that the program may be actually clinical rather than propagandist in character.

W. E. WICKENDEN,
Chairman, Program Committee.

CHANGE IN ATTITUDE OF THE PROFESSION TO ENGINEERING SCHOOLS *

By ALEXANDER S. LANGSDORF,

Dean, Washington University

This subject seems to call for some reminiscence, and it is certainly remindful of the time, not so many years after the founding of this Society, when a piece of sheepskin proclaimed me a Bachelor of Science with all the rights and privileges thereunto appertaining. Looking back, it is plain that those rights and privileges were neither numerous nor impressive; and they were most certainly coupled with plentiful warnings to go forth with eyes and ears open and mouth closed until academic theory had been duly tempered with workaday experience. That advice is good to this day, but it is not now given with the same intonation. For in those days just before the turn of the century, the burden of most complaints concerning the shortcomings of technical schools and their graduates was their supposed emphasis upon theoretical considerations in the face of the pressing practical needs of a rapidly expanding industrial world. How many times, both in those days and since, have you and I heard "practical" engineers say that they had never found any use for calculus in solving actual problems? There was not a little pressure in the direction of training *how* to obtain results rather than to explore the reasons *why* those results followed. An example that comes to mind, an incident of my senior year as an undergraduate, is perhaps typical: One of my instructors in mechanical engineering, having heard some caustic criticisms of a young graduate who had shown abysmal ignorance concerning the standard shapes and sizes of pipes and pipe fittings, set my class to work to make complete working drawings—plans, elevations, side views, and sections—of every known variety of couplings, flanges, tees, elbows, return bends and valves. You may draw your own conclusions as to which procedure was the more foolish: the complaint of the so-called practical man which led to this outrage, or the supine acquiescence of the teacher who inflicted it upon a group of dignified but otherwise helpless seniors.

It is possible that the immaturity of undergraduate years may

* Presented at the 40th Anniversary Meeting, S. P. E. E., June 26–30, 1933, Chicago, Ill.

have contributed to a misunderstanding of conditions as they then existed; but the impression was nevertheless strong that theory was one thing and practice quite another. "East is east, and west is west"; and if ever the two were to meet in the careers of the young graduates of that time, it was not likely to occur at once. In the perspective of the years that have since gone by, one can see more clearly the changes even then impending or under way, but not yet clearly recognizable in their main trend. For in the generation dating from the Civil War, while the industrial East was expanding its activity, while the South was mending its wounds, while the West was pushing back the frontier and opening an ever new and larger agricultural domain, the needs of the growing population were met by a newly emergent class of business executives who had behind them no traditions of education and none too great an appreciation of general culture. It could not have been otherwise, for the demands for action were urgent and insistent, and even though the educated classes had had the necessary commercial spirit there would not have been enough of them to handle the situation. The same thing happened in England after the Industrial Revolution, when the center of the stage came to be occupied by new classes coming up from social strata previously submerged.

In this post-Civil War period a huge economic vacuum was in process of being filled, and circumstances being what they were, it is not strange that the industrial and mercantile world was dominated by a philosophy of rough-and-ready practicality, impatient of theoretical refinements. Quite naturally, therefore, the technical schools that were established in considerable numbers within the decade following the Morrill Act of 1862 were in the beginning schools of mechanic arts where very considerable emphasis was placed upon the development of manual skills and empirical knowledge, and only limited attention was given to theoretical courses of instruction. It is very illuminating in this year 1933 to look over the curriculum of a technical school as revealed by a catalogue of, say, 1873; a very large part of what then constituted instruction in mathematics and the physical sciences has since been relegated to high school preparatory requirements. The early graduates of these pioneer schools were definitely pointed to be "practical" men, equipped to help in the practical work of the kind that then awaited them in the outside world.

But in the decade preceding the founding of this Society a new and active influence was brought to bear upon professional engineering practice and in turn upon engineering education. Electrical devices of various types which in some instances had been merely interesting toys, took on extreme commercial importance.

The telephone, the electric motor, the incandescent lamp, the street railway, depended for their development and operation upon an acquaintance with the mathematical theory of electricity and magnetism, and considerable numbers of men had to be initiated into mysteries previously reserved for Olympian heights. The technical schools of that time responded admirably to the new needs by altering their curricula and shifting the emphasis to the underlying physical theories and their mathematical representation; and of course, during the early stages of this change some engineers who had been trained in the older empirical fashion raised that issue of theory versus practice which was still being debated when this Society was young.

The story of the development of all branches of science during the latter part of the nineteenth century and continuing to the present time is one of the most fascinating of all chapters in the long history of humanity. Professor A. N. Whitehead says that of all the great inventions which were the fruit of this outburst of the scientific spirit, the greatest was "the invention of the method of invention"—that is, through systematic research. Research—with the accent both on the first and the second syllable—became the order of the day not only in the colleges and universities where it was pursued for its own sake, but in industry where it was found to pay. There was reciprocal action and reaction between the faculties of engineering schools and those of their alumni who assisted in the technical development of industrial processes. As the technical schools grew in size, in quality of instruction, and in prestige, their graduates came to constitute a very considerable part of the active membership of the national societies which represent the engineering profession. It is therefore natural enough that the voluminous literature on engineering education to be found in the published transactions of these societies places increasing emphasis upon the importance of sound training in basic sciences. The late Dr. Steinmetz once summed up current views by saying in effect that the schools should concentrate upon those essentials which cannot be learned effectively under the pressure of daily routine in the outside world.

Presently, however, a new note appeared in the symphony of advice to which engineering faculties listened attentively and sympathetically. Industrial establishments, as they grew to ever larger proportions, found it increasingly difficult to manage their activities along the old familiar lines. The importance of the human element emerged as a factor to be taken into the reckoning.

In the course of the survey undertaken under the auspices of this Society and the Carnegie Foundation, and in which the national engineering societies co-operated, there was promulgated the striking conclusion that the primary educational aim should be the

development of the intangible elements of integrity, character, and those personal qualities essential to leadership, and that training in factual knowledge should be secondary. This conclusion certainly marks a profound change in the attitude of the profession as contrasted with that which prevailed forty or fifty years ago It is a change to which the public at large subscribes to a greater or lesser degree. I recall an editorial that appeared some twenty years ago in an influential metropolitan newspaper commenting upon a report of the then Chief of Engineers of the U. S. Army concerning a proposed 14-ft. channel in the Mississippi River. General Bixby had included in his report not only a presentation of the engineering aspects of the plan but also a discussion of its economic implications. The editorial writer of that time berated the General for overstepping his jurisdiction; for, he maintained, it is the function of the engineer to deal with technical feasibility and construction details, leaving to business men and their legislative representatives the decision as to whether such a project was or was not in the public interest. It is interesting to add that the same newspaper, in an editorial printed just a few months ago, took quite the opposite view, stressing the point that engineers and scientists, having done much to get the world into an economic mess, share the responsibility of getting it out again.

This outline has briefly sketched the changes which are of importance to us as teachers of engineering. I have described them as they appear to me; others may look at them from a different angle, but in any event there has been a marked change in the period under discussion, and we would probably all agree that the end is not yet: that a new shift of emphasis is impending. It is, I believe, a fair statement that engineers as a group have been the hirelings of the business world, doing the bidding of leaders whose background has been neither scientific nor social, and whose scale of values has been expressed in terms of the amount of money to be made in business. Here and there exceptions to this general rule have occurred, and it is also true that in recent years business executives of great ability have come in increasing numbers from the engineering ranks. But in the main the great bulk of business has been unethical in the sense that it has not been motivated by considerations of social justice, and the engineering profession has played the game without conscious thought of the social and economic consequences of its contribution. This I maintain notwithstanding the classical definition that engineering is the art of directing the forces and materials of nature for the use and convenience of mankind; for while engineers have designed and built the mechanisms which in the aggregate spell an imposing industrial civilization, neither they nor the promoters who willed it into being gave due thought to its effective use for the greater happi-

ness of humanity as a whole, as the events of the last four years have rather conclusively demonstrated. The dominant motive throughout has been that of profit over and above a fair return. Mr. Raskob described the case very completely and very tersely when he spoke of the attractiveness of the "profit side of business." But now there has appeared above the business horizon the dark cloud of the law of diminishing returns, most distasteful to men who always thought of the curve of progress as a thing forever rising, with no such disturbing characteristics as points of infexion or maximum. Most disturbing of all, there is a dim but growing perception that in the field of finance, as in the scientific laboratory, there is an inexorable law of conservation: That it is not possible, indefinitely, to take out of a system more than is put in. How long that chastening lesson will last it is difficult to say, for the gambling instinct in the human animal is both ancient and powerful. It seems to me that the engineering profession can render effective public service by driving home the lesson we have all been getting in the recent past.

It is my hope that the profession as a whole will envisage its mission in terms of a wider and more responsible public service. The schools of engineering can lead the way, or at least assist in the process, by emphasizing to students the deep significance of the work they will be called upon to perform in their subsequent careers. No material changes in curricula are necessary to bring this about. It is a point of view that is to be inculcated, or, if you like, indoctrinated. Such a program is a vital step in the building of a new social order, the exchange of an outmoded scale of values for one in keeping with the grandeur of the civilization that it is in our power to build. It calls for strong and wholesome personalities in the teaching profession, for teachers of wide reading, sufficient experience with affairs, and broad tolerance. No faculty is ever likely to have more than a few such demigods at a time; but a few of them, or even one, will in time leaven the lump.

In conclusion, let me express the hope that those engineering schools which are located in urban centers will make increased use of their opportunities to interest members of the engineering profession in extension courses, or post-graduate courses of a kind which engineers will more and more need to pursue. They need to know more about economics, more about sociology; but behind these lie all the great fields of history and literature for which there is, alas, no room in the crowded undergraduate curriculum, and without which no one is truly equipped to sense the drift of things. Adult education for engineers offers a way out of the difficulties which all makers of curricula understand; is it too much to hope that the profession as a whole, through its national societies, will support such a movement?

IMPROVEMENT IN TEACHING WITH SPECIAL REFERENCE TO CHEMISTRY AND ENGINEERS *

By O. J. STEWART,

Professor of Chemistry, University of Kentucky

I have been asked to consider with you the problem of teaching chemistry to engineering students. Henry Ford recently made the remark that he had always supposed that if one were to run a business it would first be necessary for him to know something about that business. I have great respect for Mr. Ford's opinion. If it is necessary for one to be an engineer in order to consider the problem in hand, then I am out of place for I am not an engineer. I do not apply science to production. However I do teach chemistry to engineers and I presume it is for this reason that you have honored me. Personally I believe it is not necessary for one to be an engineer in order to teach chemistry to engineers. In fact I believe it is better for the students if the chemistry teacher is not an engineer for thereby the variety of the students' experience is increased. But we shall take up this matter later more in detail.

I do wish to say at this time that in the University of Kentucky our task of teaching chemistry to engineers is a pleasant one. Leaving out of consideration the pleasing personal characteristics of the Southern youth, I believe the satisfactory results of our work are due to the fact that the Engineering Department has seen fit to introduce chemistry early in their course. I have found the teaching of chemistry to engineers very difficult when its consideration is deferred to the junior or senior year. Possibly the difficulty is due to the fact that most engineering students feel that chemistry is quite outside their field—and the nearer they approach their graduation day, the more they are inclined to such an opinion. Consequently my experience indicates that chemistry should be introduced early in an engineer's course.

In this talk I propose to offer no definite plan which deals with such details as visual aids, types of examinations, segregation, methods of presentation, grading of work done, etc. Instead I wish to consider with you a phase of the problem which I believe has to do more exclusively with the college level in teaching. My pro-

* Presented at the Kentucky Section, at Lexington, Ky., December 16, 1933.

posal may seem to bear somewhat the character of the "laissez faire" principle—the "let her go Gallagher" method of conducting affairs. It may even smell somewhat of bolshevism, if by chance it appears to deviate too far from the common path of practice and of thought. You may even recognize a shadow of hopelessness in the task of improvement and also a gleam of optimism in the discovery that inadvertently we have been following the right path all along. Finally the whole scheme may appear at once visionary, impractical and foolish. But such as it is, I offer it with the remark: What more could be expected from one of the old school who believes teachers, like poets, are born, not made?

The question comes to my mind: What is good or bad teaching? How can I recognize a good or a poor teacher? I doubt if we could get together unanimously on this question. I clearly recall a definition of teaching which my father frequently quoted. In his early manhood, my father was a teacher and although he later gave up that profession for the ministry, he never lost interest in his first love. For his definition he went to the dictionary. There he found: "Teaching is causing another to know." Good teaching then would involve the best methods for causing another to know and a good teacher would be one who is proficient in causing others to know.

I doubt if this definition is satisfactory. I believe we can all agree that the teacher's duty goes far beyond the requirement of this definition. Our duty is to do what we can to prepare a man for carrying on his life's work successfully—to make his lot a happy and useful one. Some of our most successful practitioners were not noted for their book learning while in school and some of our flattest failures in life were "A" students in college. It would appear that causing a student to know is not the only aim of a teacher or of teaching. Of course the acquisition of a reasonable proportion of subject matter is necessary—but the acquisition of subject matter alone is far short of the mark all have set.

Suppose we assume for the time that two of the most important duties of the teacher are, (1) to cause a student to know and (2) to develop character and help the student to find himself and to fill his place in the world. The teacher has these two duties to perform, not on a group of students of uniform and unvarying characteristics but upon a group all different one from the other. Each succeeding year the process is repeated—but no two students are alike. This is a complicated problem.

I believe the saving graces of the whole proposition are that no two teachers are alike and that the students come in contact with many teachers. If one best set of rules of conduct and teaching were known and if all teachers could adhere to this perfect set of

rules, satisfactory results could be attained only if all students were alike and if their conduct and absorbing abilities conformed to this set of perfect rules. The very fact that students differ, requires that teachers differ.

Many attempts to solve teaching problems have been made. Segregation on the basis of scores in intelligence tests is a noble experiment. The great trouble with it is that if the scheme had been tried a number of years ago, many of our illustrious scholars would have been placed in the dumb division.

Let me describe one teacher's method of presenting a subject. This teacher is located in a large Eastern university. He proceeds as follows to teach a student to determine nitrogen in an organic substance. He hands the student the book of procedures, shows him the combustion room, tells him to go to it, then takes his departure and is seen no more unless something blows up.

A student who had submitted to this treatment told me what happened in his case. He worked for an entire week and failed absolutely. He couldn't make the thing work. At last, in the depths of despair, he concluded that he was disgraced and might as well go home to mother. He put away his apparatus, locked his desk, took his hat and departed. But as he passed through the door the teacher saw him and inquired where he was going. The student replied that he was getting nowhere and he saw no use to continue and was going home. The teacher suggested that they return to the combustion room and look things over and try to discover the trouble. The trouble was immediately found for a glass tube had been heated too hot and a hole had blown through its wall thus stopping the desired process. The student then went to work and satisfactorily finished in two hours a task at which he had bungled for a solid week. He subsequently won his doctor's degree and now is a full professor in a large state university.

After telling me of his experience he said: "That man is the prize poor teacher." My reply was that I'd bet that of all the work he took, that particular experiment was the one which he remembers best and that it helped him more than other experiments which went off smoothly. To myself I said I was quite confident the teacher knew at all times what was going on. Possibly he had gone to the combustion room in the evening after the student had left and knew the tube had been blown out. He was watching developments, he was watching the boy squirm, he was hoping the student would find the trouble. Otherwise, how did it happen that he, at the last moment, should see the student passing through the door. He had waited as long as possible. He then offered his assistance.

There was a teacher who would be called poor by many, yet

I believe that particular student required just such a lesson to teach him that he must learn to stand on his own feet. He had had at his elbow too many instructors ready to relieve him of all responsibility. Doutless it would be unfortunate if all teachers were like the one described, but a sprinkle of his breed is desirable for the benefit of certain students—and possibly for all students at some time in their careers.

I am quite intimately acquainted with teaching in a number of colleges and universities which are fairly representative of the schools in our country. I have seen what I would call good teaching and poor teaching. Judging by the results of teaching I am about prepared to conclude that the success or failure of students is independent of the teaching abilities of their professors—when teaching ability is judged in the usual off-hand way. If only the so-called good teacher can turn out good students, why is it that all schools, despite the fact that they have poor as well as good teachers, can point proudly to their illustrious sons? They all can and do.

Let me state in a few words the thesis which I defend: At the college level, what we mean by teaching is development. The acquisition of a reasonable proportion of subject matter must be insisted upon as a minimum requirement, but the development of resourcefulness is vastly more important. The saving grace of our educational system is the fact that students come in contact with many teachers, no two of whom are alike, so the probability is good that a happy combination of teacher and student may be effected.

This thesis may require further supporting evidence and amplification. Suppose a student associates with five teachers per semester. His four years' course would bring the number to forty. Every student then has during his college course forty chances for an awakening; all the time of course the teachers in their own peculiar ways, are carrying on the formal routine work of causing the student to know. Let us suppose further that the corps of teachers has been picked with great care for broad experience not only in research but also for contacts with great teachers. If a student comes in contact with forty teachers during his undergraduate work, then surely each of his carefully picked teachers has been in contact with at least sixty teachers because of graduate and post graduate study. The sixty teachers of the teacher indirectly exert their influence upon the undergraduate. The student's contacts then multiply to forty times sixty, or twenty four hundred. I can conceive of no simpler method for greatly increasing the student's contacts.

If any one doubts the stimulating value to be derived from an experienced person, let him pump some old sea captain, an old army officer or a captain of industry. Age is not the all-important

thing, but experience is. A man like Lowell Thomas can put more desire for action into a youth than can a hundred lesser lights.

I was once a student of Professor Ransom; Professor Ransom had been an assistant to the great teacher Alexander Smith; Alexander Smith had studied in Edinburgh and Munich. I could recognize the influence of Alexander Smith almost undiminished and now and then the influence of the European professors was even apparent. The aforementioned number, twenty-four hundred, is then not so excessive for it takes into account the influence of teachers only once removed while the influence of teachers twice removed can be felt. At all events, the point I wish to make is that teachers do carry with them the moulding effects of their own past teachers and their experiences and therefore it is desirable that our students should be provided with as lengthy a list of teachers as possible and these persons should have as broad a background as it is possible to secure. To put it concretely—improvement in teaching can be secured by providing a great array of inspiring leaders.

It may be that active investigators in the field of educational improvement would consider it a backward step to acknowledge that the multiplicity of requirements makes impossible the formulation of a general scheme of teaching applicable in all or nearly all cases. To recognize an impossibility is no disgrace. Does the mathematician call it a disgrace that he should fail to arrive at the precise ratio between the radius and circumference of a circle? Does the expert in thermodynamics consider it a disgrace that he should be forced to refer to perpetual motion as an impossibility? Is not the physicist rather proud that he has discovered the impossibility of measuring, accurately and simultaneously, the velocity and position of an electron in an atomic orbit? If experts working with inanimate units as much alike as two peas find problems with which they cannot cope, is it less to be expected that experts working with highly complex subjects, possessed of a will of their own, should find problems beyond their ability to solve?

Finally I should like to say a few words on a phase of teaching which does not bear directly on the subject as I have treated it. It deals with the character of the chemistry offered to engineers.

We often see texts with such titles as: Chemistry for medical students; Chemistry for home economics students; Chemistry for engineers; etc. The principle which engenders such texts is that, whereas a course in chemistry, as ordinarily given, covers considerable territory, the authors of these short course texts believe special students need concern themselves only with those particular problems which will come up later in their professional careers. One recognizes in such offerings the confidence which the authors have

in their own ability to predict the future not only for the student but also for industry as well. However the last twenty-five years and especially the last fifteen years have demonstrated how difficult it is to predict the future. Both styles and employment change. We have no way of knowing how soon a particular business or a particular process may be eliminated.

At the last meeting of the Southern Association of Colleges and Secondary Schools, President H. M. Wriston, of Lawrence College, dwelt at length on the assertion that the demand for training in a specific line is doomed for it looks to a definite future. I believe it was in his final report to Harvard Trustees that President Lowell voiced substantially the same note.

In accord with the wisdom of these thoughtful and farseeing men I suggest that engineers be taught chemistry not for engineers but just plain unadulterated chemistry which looks to no definite future. The student may then apply his training in after years as the requirements demand.

A LAYOUT COURSE

By C. C. WILLIAMS,

Dean, College of Engineering, University of Iowa

Six years ago, at the University of Iowa, a two semester hour course was inaugurated under the name, Engineering Development, which bears a relation to the entire engineering curriculum somewhat analogous to that which a layout drawing bears to the entire set of plans for a structure or other engineering project. Required in the first semester of the freshman year, it is a survey of what comprises engineering in its general outlines and of the elements which compose a proper preparation for the profession.

In this approach, the entire student's course is considered somewhat as an engineering project, involving preliminary investigations, a design, and an execution. In the project of engineering education, the layout is believed to be as essential a part as is the comprehensive layout plan for a power plant or other physical engineering enterprise. Such a layout serves to show relationships of types of training and why the detailed parts which constitute the composite whole of an engineering education are selected as they appear in the curriculum. A few of the objectives and results of the course will show its general character.

Orientation is naturally one of the aims, and this part seeks not only to orient the student as to his course and work in college but also with reference to his professional career. Therefore, not only information concerning the scope of the various branches of engineering is included, but standards of performance, ethical ideals, criteria of correctness, and a glimpse at the part that engineering has contributed to modern civilization are also presented. How to study efficiently, how to take examinations successfully, how to use the library, and the significance of extra-curricular activities are given attention and discussed in conference in a way that helps to adjust the student to his college.

A succinct review of the history of engineering in easy narrative introduces the student to the technical vocabulary, permits an elementary explanation of fundamental engineering principles in connection with invention and development, and affords background for further study somewhat as a synopsis of preceding chapters of a romance permits one to understand subsequent parts. The historical review, although educational in itself, serves effec-

tively as a vehicle for conveying a certain amount and character of instruction compatible with the student's technical comprehension in his first year, which is the period when he is most avid for technical knowledge and through which his initial interest in engineering needs to be conserved.

The need of conserving the interest and enthusiasm which prompts the student to enter an engineering college has been widely recognized and various measures have been tried to that end with various degrees of success. The youth enters college hoping to study engineering, but he is set at such subjects as algebra, chemistry and English, and finds no mention of a radio station, an airplane, a suspension bridge or a steam turbine, the sort of things that he goes to college to study. To place elementary instruction in these subjects early in the curriculum is not practicable because such instruction anticipates what comes later and must be repeated. The historical review is, therefore, the more effective device.

The layout course includes a series of easy problems involving engineering terms and conceptions designed to teach the student how to think quantitatively as an engineer thinks. These problems involve no mathematics beyond arithmetic or simple algebra, and little, if any, new instruction, but require a recalling of past instruction and experiences together with a measure of creative technical thinking on the part of the student. By thus taking stock and refurbishing his mental equipment, the freshman is better accoutered to go forward. At the same time there is no lost motion through anticipating instruction that must be repeated later when the student is better prepared to understand the more complex aspects of the matter.

In this course on "course and career," as the layout course might be designated, the student, instead of accepting blindly on faith a program of study set up for him by a faculty and an adviser, is led to see the reasons for including the various elements in the design of his curriculum and to observe its unity of purpose. Consequently, he more readily accepts the whole. Instead of being asked to take a capsule already prepared, he observes the compounding and grasps the significance of each ingredient.

This feature of the course, together with a certain amount of inspirational depicting of great engineering triumphs with some retention of the *dramatis personnae*, preserves the romance of engineering to a degree and constitutes a motivating force that secures more steady and persistent application on the part of the student. The result is that he gets his stride at once and his accomplishment in his first two years compares more favorably with that in his last two. The effectiveness of the first two years being very considerably increased, the time spent on the layout course (1.5 per cent

of total) is justified, even neglecting the intrinsic values of the course itself.

A text book has gradually evolved in mimeographed form (now being published), which embodies the substance of the course under three divisions. The first part is directed at orientation largely; the second part, being historical, affords background and perspective; and the third part aims at motivation through inspirational achievements in engineering.

Measures of the results of this layout course are naturally rather vague. However, the following observed general *sequelæ*, some of which may not be directly traceable to this cause, may be mentioned:

a. The loss of students through indifference has decreased, especially in the freshman and sophomore classes.

b. The loss of good students by transfer to other colleges has almost ceased, except that last year the uncertainty of a future in engineering caused some to transfer to liberal arts with a view to public school teaching.

c. There is some evidence that student effectiveness has increased, such as an advance in freshman and sophomore average grades.

d. The students more readily accept the required non-technical courses, such as public speaking, English, accounting and economics.

The effectiveness of the course is peculiarly dependent upon the quality of the instruction. In this college, the sections are conducted by full rank professors of engineering with mature experience, who are ready to follow up in a satisfying manner any question raised by members of the class and to supplement with details where needed.

Summarizing, the "layout course" accomplishes the following objectives:

1. It gives a background by means of historical setting, serving as a synopsis of preceding chapters and showing the evolutionary character of engineering.

2. It introduces the student through easy narrative to the vocabulary of engineering.

3. It orients the student's own aptitudes and interests to his college course and to his career.

4. It enables the student to grasp the why and wherefore of the curriculum with the result that his confidence in its merit is increased and his effort is more readily enlisted.

5. It conserves the student's initial interest in engineering through the period of assignment to duller preparatory subjects prerequisite to technical studies.

6. It illustrates the quantitative character of an engineer's thinking.

7. It outlines the methods of acquiring efficient study methods and emphasizes the function of college training as a development of mental power through orderly habits of thinking.

8. It calls attention to the phase of education that concerns attitudes and standards as supplementing the development of intellectual capacity.

9. It motivates the student to application and inspires him with a desire and a will to achieve.

10. It stimulates inquiry, discussion and creative thinking on the part of the student.

Distinct progress in all of these lines may seem, perhaps, an extravagant claim, and, of course, the extent to which results are obtained is relative. Although numerical evaluation of the improvement cannot be formulated at present, yet that an advance is discernible is generally recognized and gain is indicated in certain instances by a study of the records.

The experience at the University of Iowa indicates that the "layout course" affords a proper psychological approach to the curriculum by furnishing the general outlines preceding details and that, because of the catalytic effect on the student's performance in his other subjects in addition to the intrinsic values of the study itself, the course yields large dividends on the time investment.

AN EARLY COURSE IN CHEMICAL ENGINEERING

By D. B. PRENTICE, President, Rose Polytechnic Institute

At the fortieth anniversary meeting of the Society for the Promotion of Engineering Education, Professor Hammond presented a paper on "Promotion of Engineering Education in the Past Forty Years" (printed in the September 1933 Bulletin, p. 44 et seq.) in which the following statement occurred:

> "The first course in chemical engineering was announced by the Massachusetts Institute of Technology in 1888, the first program of this type to be established in this or any other country. The second curriculum in chemical engineering was offered at Michigan in 1895."

Recalling that Mr. Walter B. Wiley received the degree of Bachelor of Science from Rose Polytechnic Institute in 1889 for completing a four year course in chemical engineering, the writer has searched the early records and catalogs of the Institute for material which would establish a prior or at least simultaneous claim with M. I. T. for the establishment of a curriculum in this field. The results of this search are presented herewith as a contribution to the history of engineering education in the United States. In passing, it should be stated that Mr. Wiley received the professional degree of Chemical Engineer from Rose in 1917 and is now Chemical Engineer with the Illinois Steel Company at South Chicago.

Although Rose Polytechnic Institute was chartered in 1874, the death of Mr. Rose in 1877, delays connected with the settling of his estate and the construction of suitable college buildings postponed the actual beginning of instruction until March, 1883. At that time, Dr. Charles O. Thompson, a graduate of Dartmouth and previously President of Worcester Polytechnic Institute, was inaugurated as the first President of Rose. After his election in 1882, Dr. Thompson had spent several months in Europe studying technical education and his inaugural address contained many references to ideals and practices in the great engineering schools of France, Switzerland, Germany, Austria and Russia.

In defining his plans for the new Polytechnic Institute Dr. Thompson stated: . . . "So that a polytechnic school, by whatever name called, technological, technical or engineering, teaches technology to engineers, *i.e.*, it teaches the principles of physical science and their application to the industrial arts. . . .

"The names applied to the different branches of engineering are not always appropriate, but, in general, a civil engineer constructs public works, such as highways, railroads, water works, sewers, etc.; a mechanical engineer deals with machinery, from the original design of each part, through the machine shop and into the structure and to the operation of the structure, *i.e.*, the machine; the chemical engineer applies chemistry to the manifold products that result from the play of chemism." Although brief, the last clause is a definition of chemical engineering to which little would have to be added to-day.

While not particularly pertinent to this discussion, the closing sentences of Dr. Thompson's paragraph defining the preparation which would be expected of candidates for admission to Rose are worth repeating for the cleverness of the metaphor. "The polytechnic is a professional school, and must concentrate itself upon its own special work; but the broader the base upon which it builds, the more massive the structure that can be reared. Whether the polytechnic course shall rear an obelisk or a pyramid depends on the preparation of its students."

The early catalogs of Rose are curious publications considered by comparison with the modern technical school bulletin, and very little specific information as to curricula is presented. The catalog of 1888, however, for the first time presents the programs of the civil, mechanical and chemical courses.

The chemical course was identical with the mechanical for the freshman year and included the following subjects: algebra, geometry, trigonometry, free-hand and mechanical drawing, elementary mechanics, elementary physics, elementary chemistry (beginning second term), foreign language and shop work.

In the sophomore year the study of mathematics covered spherical trigonometry, analytic geometry, determinants and an introduction to calculus. Qualitative analysis for one term and quantitative analysis for two terms were given fourteen hours per week, and a term course was required in mineralogy. To these should be added German and courses in drawing and descriptive geometry.

The program for the junior class comprised courses in differential and integral calculus, theory of least squares, analytical mechanics, physics, German and organic chemistry with one lecture and fourteen hours of laboratory work per week throughout the year.

In the senior year the chemical engineering aspects of the program were emphasized. Courses were required in metallurgy, fuels, chemical theory and history and chemical technology, the latter through three terms. Applied mechanics and thermodynamics also ran for the entire year with term courses in physical

laboratory and engineering laboratory (steam, power and materials testing). French, English and a thesis completed the program.

This curriculum differs very little from a modern course. No very detailed statements of the several subjects are available, but apparently chemical technology emphasized manufacturing processes as reference is made to careful study of a number of nonmetallic products and their manufacture. This course must have included consideration of unit processes.

The faculty of Rose in 1888 included Professor T. C. Mendenhall, physics; Professor William A. Noyes, chemistry; Professor Malverd A. Howe, civil engineering, and Professor Thomas Gray, dynamic engineering. Brief records of these men will give the reader some idea of the quality of instruction Rose undergraduates of the late '80's enjoyed.

Thomas Corwin Mendenhall, Ph.D., LL.D., Sc.D., was professor of physics at Ohio State University and at the Imperial University of Tokyo from 1873 to 1884, when he became Chief of the United States Signal Corps. Dr. Mendenhall came to Rose in 1886 and resigned to become Director of the United States Coast and Geodetic Survey. From 1894 to 1901, when he retired, he was President of Worcester Polytechnic Institute. Dr. Mendenhall's public service included also the superintendency of Weights and Measures for the United States and membership on the United States Lighthouse Board and the Behring Sea Commission. He was awarded a gold medal at the Paris Exposition and by the American Geographical Society for his work in seismology and chartography.

Thomas Gray, Ph.D., was a graduate of the University of Glasgow and an assistant to Sir William Thomson. While at the university he received the Cleveland Medal for his work in magnetism. After holding a professorship at the University of Tokyo, Dr. Gray returned to Scotland as Lord Kelvin's assistant. He served as engineer for the manufacture and laying of the Commercial Company's two Atlantic cables and wrote the article on the electric telegraph and telephone for the Encyclopedia Britannica.

While a member of the Rose faculty, Dr. Gray prepared the Smithsonian Physical Tables of 1895 and the revisions of 1897, 1903 and 1904 and invented many scientific instruments in the fields of mechanics and electricity.

Malverd A. Howe, B.S., M.S., C.E., became a member of the Rose faculty after some engineering practise with the Edge Moor Bridge and Iron Company and a year on the faculty of Harvard. Professor Howe is perhaps best known as the author of numerous text and reference books in the field of civil engineering and for his consulting work on bridge design and construction.

William A. Noyes, Ph.D., LL.D., Chem.D., Sc.D., graduated from Grinnell College and Johns Hopkins. After three years at the University of Tennessee, Professor Noyes became head of the department of chemistry at Rose, a position which he held for seventeen years. From 1903 to 1907 he was chief chemist of the Bureau of Standards and from 1907 to 1926, professor of chemistry and director of the laboratory at the University of Illinois. For fifteen years Dr. Noyes edited the *Journal of the American Chemical Society* and in 1920 was President of the Society. In 1908 Dr. Noyes received the Nichols medal, and was awarded the Willard Gibbs medal in 1919.

When it is realized that the total enrollment of Rose at that time was about 110 and that most of the instruction was given by the department heads to small sections, the quality and thoroughness of the training can be appreciated. A chemical engineering graduate who had followed successfully the curriculum presented in the Rose catalog of 1888 under the teachers and conditions of those days must have compared favorably in preparation with the graduates of any other colleges of engineering in the United States. The training may have been in advance of the appreciation and demand from chemical industries, but it was, without doubt, excellent preparation for achievement and service in this field.

RELATION OF SECONDARY SCHOOL PREPARATION TO SUCCESS IN THE COLLEGE OF ENGINEERING

By CHARLES W. BOARDMAN and FRANK H. FINCH,

University of Minnesota

A number of workers[1] have studied the relation between the pattern of units of credit earned in high school and success in college as measured by instructors' marks. The general conclusion of these studies is that no specific subject or group of subjects possesses greater value than any other as a determinant of successful achievement in college. These investigations have been confined primarily to studies in liberal arts colleges and little attention has been directed to the study of achievement in engineering colleges, despite the fact that the common custom in such schools has been to require credit in specified fields in high school as a prerequisite to admission to engineering curricula.

In their survey of requirements in thirty-one institutions which they classify as colleges of agriculture, applied science and technology, Brown and Proctor[2] report that eighty-six per cent admit principally upon certificates of high school credits, the remaining fourteen per cent depending upon such certificates and certain supplementary materials. Of the thirty-one schools, fifty-five per cent required high school credit in languages for admission to college, sixty-five per cent required credit in science, and eighty-two per cent required credit in mathematics for entrance. On the other hand, only thirty-nine per cent would accept for admission as much as five units of credit in the vocational-commercial-industrial fields. Three per cent accepted four units of this type as credit for admission, and fifty-five per cent limited the amount accepted to three units or less.

In view of these practices in admitting students to scientific and technological institutions, it seems desirable to investigate the validity of such procedures. The problem of the present study is to

[1] For a review of these studies see Douglass, Harl R.: *The Relation of High School Preparation and Certain Other Factors to Academic Success in the University of Oregon*, pp. 35–41. University of Oregon Publications, Education Series, Vol. 3, No. I, 1931.

[2] Brown, Edwin J., and Proctor, Wm. M.: "Methods of Admission and Matriculation Requirements in Three Hundred and Thirty-one Colleges and Universities," *Seventh Yearbook of the Department of Superintendence*, pp. 331–58, Washington, National Education Association, 1928.

discover what groups, if any, of high school courses contribute most to achievement in the College of Engineering at the University of Minnesota. The data consist of the complete high school and college records of one hundred thirty-nine students who entered the College of Engineering and Architecture in the Fall Quarter, 1924. The requirements for admission to this college at that time were as follows:

	No. of Units
Required Subjects	
English	4
Elementary Algebra	1
Plane Geometry	1
Advanced Algebra	½
Solid Geometry	½
Total Required Units	7
Elective Subjects	
Academic Fields	4
Free Election—Any Field	4
Total Elective Units	8

In the published Bulletins of Information the College of Egineering recommended that students offer chemistry and physics as part of their elective units. It should be noted that this institution was unusually liberal in the number of free electives, four being accepted from any field of study, which includes the vocational-commercial-industrial groups of subjects.

The sources from which the subjects of this study came to the University of Minnesota were as follows:

Minneapolis, St. Paul or Duluth	73
Smaller communities in Minnesota	49
Communities outside of Minnesota	17
Total	139

The subjects were distributed among the various curricula in the College of Engineering in the following proportions:

Architectural Engineering	20
Civil Engineering	21
Electrical Engineering	39
Mechanical Engineering	10
Not designated	49
Total	139

The number of subjects was considered to be too small to make desirable any analysis of sub-groups, either on the basis of source from which they came or of the curriculum chosen.

Four criteria have been employed as measures of achievement in the College of Engineering and Architecture. While no one of them, nor the total group, can be defended as a perfect measure of achievement, it is believed that each is of value in differentiating between groups of students who do well and those who perform poorly in their professional courses. All four criteria are accepted by the College of Engineering as measures which do differentiate between students.

The first of these criteria is the total amount of credit earned in the College of Engineering from the date of entrance in October, 1924, to the close of the school year 1929–30. This criterion uses the gross amount of college credit earned as a measure of success. The second criterion, in which both quantity and quality of achievement are taken into consideration, is the total honor points earned by a student. The number of honor points earned by a student is obtained by assigning a weighted value to the number of quarter hours of credit earned in a course in accordance with the instructor's mark. The following table shows the basis upon which these weighted values are assessed:

HONOR POINTS ASSIGNED EACH QUARTER HOUR OF CREDIT ACCORDING TO THE INSTRUCTOR'S MARK

Mark	Honor Points per Credit Hour
A	3
B	2
C	1
D	0
F*	—1

* The mark F denotes failure.

The third criterion is a measure of quality of college work. It consists of the ratio between total honor points and total credits earned. The fourth criterion is the percentage awarded degrees by the College of Engineering.

The method used in the analysis of these data has been to classify the students in groups according to the amounts of high school credit offered for college entrance in each subject field, and then to compute the median and quartile points for each group in each of the measures of college success.

The same points of reference were computed also for each group according to the percentile ranks upon the College Aptitude Test, a psychological test given at college entrance which is presumed to measure intellectual capacity.

The results of this analysis (Tables I to IV) enable one to observe the general trend in performance upon each criterion as one

passes from those having little high school credit in a specific subject matter field to those having larger amounts of such credit. For example, the third quartile in total hours credit earned by students who offered one or two units in high school social studies for college entrance (Table I) was 208.2, by those who offered three units was 205, by those who offered four or five units was 205.7. For the whole group the third quartile in total hours credit was 206.8. All other tables are to be read in this same fashion.

In the comparison between the amounts of high school credit in the social studies (Table I) and each of the four criteria the same

TABLE I

THE RELATION OF THE EXTENT OF COURSES IN HIGH SCHOOL SOCIAL STUDIES TO SUCCESS IN THE COLLEGE OF ENGINEERING

No. of Units		1	2	3	4	5	Total
N		15	43	51	27	3	139
Total Hours Credit in Engineering	Q_3	208.2		205	205.7		206.8
	Md	120.0		90	120.0		105.0
	Q_1	38.0		36	20.0		34.4
Total Honor Points	Q_3	208.3		193.8	168.8		191.7
	Md	100.0		112.5	41.6		69.4
	Q_1	18.8		10.0	14.3		13.8
Honor Point Ratio	Q_3	1.09		1.125	.90		1.08
	Md	.683		.654	.583		.654
	Q_1	.375		.20	.292		.30
Per Cent Graduating		46.6±4.4		39.2±4.6	36.7±5.9		41.7±2.82
College Aptitude Test Percentile Rank	Q_3	82.8		79.2	73.5		81.6
	Md	64.3		49.0	51.0		58.7
	Q_1	32.8		35.3	28.5		32.6

trend is observable; those students having the smaller amounts of credit tend to surpass in engineering achievement those who have larger amounts. The difference between each of the groups is small and the trend is not perfect at each point of reference. It is quite possible that the differences noted are to be accounted for by the fact that the same relationship is found between the ranks on the College Aptitude Test and the amount of credit in the social studies, those who scored highest on the test tending to take less course work in the social studies in high school.

In the case of high school foreign languages (Table II) the trend is in the opposite direction, those who have the most high school credit in this field tending on each of the criteria to surpass those

TABLE II

THE RELATION OF THE EXTENT OF COURSES IN HIGH SCHOOL FOREIGN LANGUAGES TO SUCESS IN THE COLLEGE OF ENGINEERING

No. of Units		0	1	2	3	4	Total
N		45	15	57	11	11	139
Total Hours Credit in Engineering	Q_3	206.7	208.5	204.7	207.5		206.8
	Md	92.0	110.0	100.0	180.0		105.0
	Q_1	25.0	20.0	36.4	50.0		34.4
Total Honor Points	Q_3	162.5	262.5	185.0	267.5		191.7
	Md	62.5	106.3	65.0	162.5		69.4
	Q_1	15.6	6.3	15.0	18.7		13.8
Honor Point Ratio	Q_3	1.08	1.44	.95	1.38		1.08
	Md	.50	.50	.656	.75		.654
	Q_1	.313	.313	.343	.25		.30
Per Cent Graduating		35.6±4.8	53.3±8.7	40.4±4.4	50.0±7.2		41.7±2.82
College Aptitude Test Percentile Rank	Q_3	68.5	76.0	78.3	89.0		81.6
	Md	39.9	57.7	62.1	78.5		58.7
	Q_1	25.0	33.5	38.5	55.0		32.6

who have less. However, the differences between the groups on the College Aptitude Test suggest that the explanation for the apparent relationship between extent of training in high school foreign language and performance in engineering courses does not lie in the fact that these students were exposed to larger or smaller contacts with the contents of high school language courses, but that the difference is dependent upon some ability measured by the College Aptitude Test and found in greater degree in those individuals who have taken larger amounts of foreign language in high school.

When the amount of credit in high school science (Table III) is considered the picture changes somewhat. There is no general trend from one group to the next in ability as measured by the College Aptitude Test, nor is there any definite evidence of a shift in quality of work in engineering courses. However, in both the total amount of credit earned in engineering courses and the proportion who received degrees there is a fairly regular gain as one passes from those having the least to those having the most training in high school science.

More extensive training in high school mathematics (Table IV) apparently accompanies higher performance on the College Aptitude Test, and here each measure of achievement in college likewise shows rather decided improvement as the amount of high school mathematics increases. It is probable that differences in the de-

TABLE III

THE RELATION OF EXTENT OF COURSES IN HIGH SCHOOL SCIENCE TO SUCCESS IN THE COLLEGE OF ENGINEERING

No. of Units		1	2	3	4	5	Total
N		28	50	45	12	4	139
Total Hours Credit in Engineering	Q_3	207.5	205.0	207.2	208.5		206.8
	Md	95.0	110.0	115.0	140.0		105.0
	Q_1	25.0	38.3	33.3	30.0		34.4
Total Honor Points	Q_3	162.5	212.5	166.7	187.5		191.7
	Md	58.3	50.0	108.3	87.5		69.4
	Q_1	8.3	13.3	21.4	12.5		13.8
Honor Point Ratio	Q_3	1.00	1.20	1.00	.937		1.08
	Md	.625	.656	.659	.625		.654
	Q_1	−0.125	.30	.531	.083		.30
Per Cent Graduating		32.1±5.9	38±4.6	46.7±5.0	50±8.4		41.7±2.82
College Aptitude Test Percentile Rank	Q_3	76.0	88.5	83.1	90.0		81.6
	Md	53.5	62.7	57.0	53.5		58.7
	Q_1	33.5	34.3	37.7	23.5		32.6

TABLE IV

THE RELATION OF THE EXTENT OF COURSES IN HIGH SCHOOL MATHEMATICS TO SUCCESS IN THE COLLEGE OF ENGINEERING

No. of Units		2	3	4	Total
N		43	87	9	139
Total Hours Credit in Engineering	Q_3	195.0	205.0	—	206.8
	Md	55.0	155.0	195	105.0
	Q_1	16.7	42.0	—	34.4
Total Honor Points	Q_3	131.3	206.3	—	191.7
	Md	35.0	110.7	165	69.4
	Q_1	0	18.4	—	13.8
Honor Point Ratio	Q_3	.813	1.15	—	1.08
	Md	.545	.702	.875	.655
	Q_1	−0.125	.375	—	.30
Per Cent Graduating		27.9±4.7	58.6±3.6	55.6±11.1	41.7±2.82
College Aptitude Test Percentile Rank	Q_3	77.4	80.0	84.3	81.6
	Md	52.5	59.0	78.5	58.7
	Q_1	25.0	35.0	38.5	32.6

gree of the ability measured by the College Aptitude Test accounts for both the amount of mathematics taken in high school and the degree of achievement in engineering courses.

The investigation to this point has considered only the relation between the number of units of high school credit in academic subjects and achievement in engineering courses. There remains to be considered the high school manual training courses (Table V). The

TABLE V

THE RELATION OF THE EXTENT OF COURSES IN HIGH SCHOOL MANUAL TRAINING TO SUCCESS IN THE COLLEGE OF ENGINEERING

No. of Units		0	1	2	3 or more	Total
N		35	36	26	42	139
Total Hours Credit in Engineering	Q_3	205.0	207	203.3	207.0	206.8
	Md	92.5	85	120.0	145.0	105.0
	Q_1	8.0	40	37.5	37.5	34.4
Total Honor Points	Q_3	183.3	183.3	241.7	206.2	191.7
	Md	62.5	40.0	81.3	112.5	69.4
	Q_1	10.0	10.0	12.5	21.0	13.8
Honor Point Ratio	Q_3	.95	.75	1.20	1.21	1.08
	Md	.625	.546	.75	.75	.654
	Q_1	.187	.20	.417	.50	.30
Per Cent Graduating		45.7±5.7	33.3±5.3	37±6.4	47.6±5.2	41.7±2.82
College Aptitude Test Percentile Rank	Q_3	82.2	88.5	79.7	73.5	81.6
	Md	55.0	69.0	62.5	56.0	58.7
	Q_1	34.7	38.5	32.7	26.0	32.6

association between the units of high school work in this field and the score on the College Aptitude Test is irregular and shows little relationship between the two. The extent of contact in high school with the subject matter of this field does seem to be related to achievement in engineering upon all four criteria, a definite progression being found as one passes from the group having one high school unit in this field to those having three or more. It is of interest to note that upon all four criteria those who present only one unit of high school manual training are inferior to those who had no credit in this subject as well as to those who have had larger amounts of credit, despite the fact that this group is not inferior upon the College Ability Test.

The analysis of these data seems to show that in three fields, science, mathematics, and manual training, there is a slight rela-

tionship between the amounts of high school credit and success in engineering courses. All three of these high school subjects contain one common element; they are all more or less closely related to engineering. Indeed, in colleges of engineering there are advanced courses in mathematics and science, and students engage in drafting, drawing, shop work, and other advanced phases of work resembling manual training in high school. Because of the observed relationships between extent of high school training in these subjects and success in engineering courses, and because of their similarity to certain aspects of engineering education, it was deemed advisable to combine the data for these three fields and to compare them to the criteria of success in engineering. The facts are presented in Table VI.

TABLE VI

THE RELATION OF THE EXTENT OF COURSES IN HIGH SCHOOL MATHEMATICS, SCIENCE, AND MANUAL TRAINING COMBINED TO SUCCESS IN THE COLLEGE OF ENGINEERING

No. of Units		4	5	6	7	8	9	10	11	12	13	14	Total
N		6	22	27	29	28	16	7	3	0	0	1	139
Total Hours Credit in Engineering	Q_3	195.0			214.1			209.0					206.8
	Md	67.5			135.0			201.0					105.0
	Q_1	25.0			44.0			45.0					34.4
Total Honor Points	Q_3	156.25			203.5			237.5					191.7
	Md	32.1			105.0			143.7					69.4
	Q_1	6.25			11.4			43.7					13.8
Honor Point Ratio	Q_3	.95			1.05			1.33					1.08
	Md	.54			.667			.95					.654
	Q_1	.11			.31			.625					.30
Per Cent Graduating		27.3±4.0			49.1±4.5			55.6±6.5					41.7±2.82
College Aptitude Test Percentile Rank	Q_3	82.2			82.2			77.2					81.6
	Md	57.2			63.0			49.3					58.7
	Q_1	35.2			25.0			29.7					32.6

It should be noted first that the College Aptitude Test does not show any regular trend among these groups of students, the actual performance as indicated by the points of reference being very irregular. However, no matter which measure of college success is considered, there appears to be a definite tendency for larger amounts of high school credit in these fields to be accompanied by better achievement in engineering courses, even though there is no similar increase in rank on the College Aptitude Test.

As a means of showing the relationship between these factors by another method, certain coefficients of correlation were computed by the product-moment formula. The following coefficients were obtained.

	r
Total high school credits in science, mathematics, and manual training with total engineering credits	$.194 \pm .036$
Total high school credits in science, mathematics, and manual training with honor point ratio in engineering	$.190 \pm .036$
Total high school credits in science, mathematics, and manual training with percentile rank on the College Aptitude Test	$-.030 \pm .058$

These coefficients, although low, tend to bear out the conclusions already noted, *i.e.*, that although there is no relationship between rank on the College Aptitude Test and extent of high school training in these fields, nevertheless there is some relationship between success in engineering courses and the amount of high school credit earned in these three subjects.

The limited nature of this study does not permit drawing definite conclusions concerning the relationship between performance in the College of Engineering and the amounts of high school credit earned in various fields. From the data it may be tentatively inferred that students who offer more extensive training in high school science, mathematics, and manual training, on the whole, are somewhat better prospects for success in the College of Engineering than are those students who have had slight contacts in high school with these fields. The superior performance in engineering courses of those students who have had more extensive work in these subjects at the secondary school level is dependent upon some factor not measured by the College Aptitude Test. Especially does this seem to be true of science and manual training fields. The force of the inference made from these data is increased when one notes that manual training is accepted by the College of Engineering as a free elective, and that science is not required, although physics and chemistry are recommended for election as entrance credit.

It is not safe to assume, however, that contact with these three fields, science, mathematics, and manual training, produces some ability conducive to success in engineering courses. It is entirely possible that these high school courses have been effective as a selective agent, that is, those students who take in high school the most work in these fields may possess on the average more ability for or interest in the types of material met in engineering courses.

If the results of this study are substantiated by more extended investigations involving larger groups of subjects more truly representative of engineering students in general, then it is apparent

that the practice common in many engineering colleges of declining to accept or of limiting the amount of high school manual training credit accepted for admission cannot be justified. In fact, it would appear that certain groups of students now excluded from many engineering colleges by present entrance requirements may be better prospects for engineering training than some groups now being admitted. In any event, the implications of this somewhat limited study seem to indicate that this may be a fruitful field for more elaborate investigation.

RESEARCH AS AN ADJUNCT TO TEACHING*

By JAMES ASTON,

Professor of Mining and Metallurgy, Carnegie Institute of Technology

The topic under consideration may be considered from two angles: first, research conducted by the teacher, or with which he is associated, in its effects upon the several parts of our educational set-up; second, the present day importance and trend of metallurgical research in industry as influencing the type of instruction and of curricula to meet the need.

Obviously the primary function of the teacher is to teach; he is a medium to impart information to the prospective scientist or engineer, and to guide him in a logical acquisition of subject matter. That research activity on the part of the teacher should have an integral place in the picture would at first glance seem to be irrelevant. And yet research occupies a definite place in the teaching program; increasing in importance or necessity as we ascend the collegiate scale from the undergraduate to the graduate phases of endeavor.

Let us evaluate research from the viewpoint of (*a*) the college; (*b*) the teacher; (*c*) the student. The college gains by that which is beneficial to the teacher; research also serves to enhance the reputation of the institution. The college, however, must not expect to have its cake and eat it; any insistence upon a quota of research must be compensated for by the adjustment of the teaching load, and by adequate equipment and assistance to support a commendable program.

It is beyond question that reputations of individuals or groups, built upon research activities in various fields, have been distinct assets to their institutions, and have been magnetic in attracting students. Instances in point are Haslam at Massachusetts Institute of Technology in oils, Taylor at Princeton in catalysis, Howe at Columbia and Sauveur at Harvard in iron and steel, and Mathewson at Yale in non-ferrous alloys.

The college must be careful that a too rigid advocacy of research does not react to its disadvantage. A splendid teacher may be a poor researcher; while a high type of research worker might

* An address delivered at the Mining and Metallurgical Session of the Summer School for Engineering Teachers, University of Wisconsin, July 21, 1933.

prove to be a dud in transmitting information in class. A proper balance might be the recognition of good teaching *per se*, as offsetting research activity; particularly so if the teacher has established a high reputation through some effort, and which might have equivalent value measured by the institutional yard stick.

Some teachers undertake research for love—some because of the pressure resulting from administrative policy; some for pecuniary gain; and, even though one or all of these three causes may be contributing factors, a good deal of collegiate research activity has publicity as an objective. Forced research is likely to bring a poor reward; in common with all effort, the best results are obtained where the worker is contributing a full measure of interest and enthusiasm. And yet an educational institution should be the gainer by a policy of insistence upon research, since it will tend to shake the teacher loose from the lethargy of hack or cook book instruction. Well conducted research, whether for love or with a commercial taint, is a most stimulating influence. It keeps the instructor up to date, broadens his viewpoint, and furnishes a background of illustration and experience which is a valuable adjunct in teaching.

Even to the undergraduate student, the contact with and observation of research, even remote, should have a stimulating influence. It should impress upon him that knowledge is not a static thing, that his leader must continue to search for the answer, and that there is a fruitful field for the knowledge that he may acquire. Naturally, as he develops, and as he may eventually come into direct association with research as a part of his graduate program, the benefits to the student are cumulative; with an additional profit accruing from the guidance of the teacher and experienced research worker.

One often hears the criticism that a student may go across the continent to profit by the instruction of some outstanding authority, and receive little more than an opportunity to gaze upon the great man. However, one hour a week of authoritative discourse, coupled with the inspiration of directed research in a chosen field may be ample reward.

If research is an adjunct to teaching, what form shall it take? Obviously it should be held within the bounds of the facilities and equipment afforded by the institution. Its natural trend will be along the specialty lines and inclinations of the instructional personnel. Generally speaking, the university personnel, its equipment, the type of assistance which advanced students may render, the absence of extreme urgency for results, and the non-interference of the usual day-by-day problems met in the commercial field, mark the college laboratory as an appropriate setting for pure or

fundamental research. The advancement of science is more properly the function of the college than of industry.

Much fine research work in our colleges has been upon scattered problems, individually or independently conceived and executed. If, however, the conception of a problem is the result of mature experience, and if it has the benefit of suggestion and advice from industry, so much the better. Individual conception is too likely to lack a definite purpose, or to waste energy through duplication of effort. At the Carnegie Institute of Technology we have a Metals Research Laboratory. While its research activities, both in concept and in execution, are largely of an independent nature, it has the aid of an advisory board composed of outstanding men in industry engaged in metallurgical research and production. The marked benefit of this relationship cannot be denied; duplication of other investigative work is checked, and the effort is directed along lines of promise, devoid of any tendency to ride a hobby.

The general equipment of college laboratories which aim to carry on research consists of pyrometers for temperature determinations and for critical thermal studies, metallographic microscopes and accessories, accurately controllable heat treatment furnaces, perhaps X-ray equipment, and various types of apparatus for determination of physical properties. The logical fields of application would be to the study of the internal anatomy of metals, the relations of structure to heat treatment and physical properties, and exploration for new combinations of metals and their fitness for special conditions of service. The scope may vary from the purely fundamental to work directly related to industry; depending largely upon the leanings of the personnel.

If electric furnaces or other high temperature apparatus are available, the horizon is widened, since preparation of alloys and small scale process problems may be tackled. At the Carnegie Institute of Technology we have a fair sized rolling mill; it needs no prompting on my part for you to conjure up various problems in which it could be of assistance. However, generally speaking, the institutional laboratory is only rarely fitted for the problems related to process or production, except perhaps in certain preliminary or fundamental aspects. The variables accompanying the enlarged scale of commercial operation usually result in marked deviations from the conditions indicated in laboratory development.

I confess to a bias towards research of an industrial complexion. The commercial viewpoint of application, and the economic aspects coupled with exploitation, have a beneficial influence upon the teacher in a way which cannot be duplicated by non-applied research. In fact, my ideal of the engineering teacher is one who,

in addition to the recognized qualification of ability to teach, has a background of commercial experiences. My observations of student reaction to instruction convince me that interest is aroused and attention is held where topics or principles may be illustrated by experiences drawn from the industrial contacts of the teacher. Further, there is no great gap between the research of our well organized industrial laboratories and that of our best collegiate institutions. The former may lean more to the applied phases, and the latter to the fundamental; but from a quality viewpoint, there is a parity. I feel, therefore, that high type research conducted in industrial laboratories deserves recognition by our colleges even in candidacy for the doctorate. In this respect I am at odds with the almost universal requirement that such work shall be done in residence.

It may be that where the teacher is giving his time to industrialized research, the college may lose some advertising value, due to lesser freedom of action in publication of results. Also, lurking in the background is the possible adverse publicity which may result from misuse of data or reports in commercialized advertising. At the Carnegie Institute of Technology, every effort is made to nullify this feature to the extent that reports of a private character must not be made upon the official stationery of the Institute, or upon stationery which indicates any connection of the Institute with the report in question.

It is only a small gap between the teacher in industrial research and in consulting practice. Quite often the consulting relationship is on research problems. The metallurgical teacher is of value to industry because he is an outstanding authority or specialist; because he may bring a different angle of vision to bear on projects from that of the regular staff, thus serving as a balance wheel; and because his known connection with the concern may be a good advertising stroke. The consultant surely has his experience, viewpoint, and reputation broadened and enhanced. He should be a better teacher as a result, and an added asset to the college and to the student body. The drawback so far as the college is concerned, is the general lack of publication issuing from such a connection.

Coöperation in Research

Yesterday's talk made mention of coöperative research, and certain aspects of its development in connection with non-competitive problems of industry of common or group interest. I feel that there is a definite place for coöperative research in relation to collegiate activities or associations.

Coöperation in research may be from two angles. First, a broad

problem may be dissected into component parts, which are assigned to several coöperating laboratories. There is the advantage of group guidance, avoidance of duplicate or overlapping effort, and an expediting of the solution of the problem. However, it is a human trait to be jealous of individual efforts and accomplishments; and even in a place of supposedly maximum altruism, namely the college laboratory, coöperation on a group investigation is not likely to meet with hearty approval. After all, pride in individual accomplishment, and the value of individual credit on publication, are the major incentives in non-commercial research.

The second angle in coöperative research is that arising from a common interest in a problem which will lead to support of investigation in an advisory and particularly in a pecuniary capacity, and the delegation of the research to some properly organized laboratory. It would seem logical to adopt this procedure for many of the fundamental questions in metallurgy; since few of our industrial concerns or colleges feel individually capable of financing the projects, and individual corporations can only rarely be aroused to an undertaking of expensive investigation with tangible returns which at best will be in the remote future.

A host of fundamental questions and many problems of direct utility could be studied on this coöperative basis. In addition to an apportionment of expenses, there would be the benefit of an advisory relationship with the interested supporters. While the projects would generally be too comprehensive to be undertaken as an adjunct to the normal functions of teaching and graduate research in the college laboratory, an organized laboratory affiliated with the college would appear to be the logical berth for this type of investigation.

Successful relationships of this character are the Mellon Institute, the Battelle Memorial Institute, the Research Laboratory of Applied Chemistry at Massachusetts Institute of Technology, and the Carnegie Institute of Technology—Bureau of Mines Advisory Board combinations in metallurgy and in mining. Institutions which have associated laboratories, such as the Engineering Experiment Stations of our state universities, and the Metals Research Laboratory and the Coal Research Laboratory at Carnegie Institute of Technology warrant support of a group character and are ideally constituted to render service.

I feel that the instruction divisions of a college are the gainers by an affiliation with a research organization of the type just mentioned.

The Influence of Research upon Teaching

Thus far we have been considering research from the direct angle of its conduct within the college or the contact of the teacher

with such activity and its evaluation in relation to institution, instructor and student. A phase of the general topic hardly secondary to the above is the bearing of metallurgical research upon teaching methods and curricula.

The most important factors influencing the altered conditions of our time are the marked advances in pyrometry, in microscopy, and in physical chemistry; to this, as a most recent contributor, is the X-ray. Through thermal analysis, by accurate heat control, by study of structures of metals in relation to treatment, and through the knowledge of solubility and equilibrium relations we have come into a realm of interpretation and application which was in the past largely hit-or-miss.

Certain things have become obvious in recent years with a steadily increasing directional trend. First, the graduate in metallurgy is finding his berth in the consuming as well as in the producing industries. Second, in this field his talents are being employed in control of quality of material and in the utilization of the full measure of metals properties as affected by alloying and heat treatment. Third, the demands for the best properties that metals are capable of giving, and a steady drive better to fit metals to special conditions of service and to develop special materials for such service have emphasized the importance of research and expanded the territory and the type of outlet for the talents of the metallurgist. As an indication of the trend, one notes the use in the United States of one ton of alloy steel for each 16 tons total in 1928; as contrasted with a ratio of one ton to 132 tons in 1909.

The services of the metallurgist are now employed in most of the major industries consuming metals—railroads, automobile manufacturers, oil companies, fabricators and machinery manufacturers. As close rivals of the metals producing industries, in facilities for control and research, one may cite the laboratories of the Pennsylvania and New York Central Railroads, the General Motors Corporation, the Gulf Oil Corporation and the Standard Oil Company, the Babcock and Wilcox Company, the A. O. Smith Corporation, the Westinghouse Electric and Manufacturing Company, and the General Electric Company. In a similar groove may be placed the various government agencies, such as the Navy Department, Bureau of Mines and Bureau of Standards.

The personnel needs of laboratories of the above type and the natural accompaniment of a similarly trained force in the works to meet the consumers' specifications or desires, have altered the complexion of what might once have been considered the standard plan of metallurgical instruction.

In general curricula, metallurgy has been treated as a division of engineering, and has leaned towards the process phases of the

art. At the Carnegie Institute of Technology we are in the heart of steel production of the country. The initial thought of the Institute was along the line of applied sciences, and to fit men for industry. Our curriculum in metallurgy was dominantly engineering, with mathematics, mechanics, chemistry, physics and geology as the fundamentals. Metallurgy leaned toward the process side of iron and steel. While we feel that this is a logical set-up, we have been forced to recognize the changed trend by offering optional training along the lines of physical metallurgy. The principal change in fundamental subjects has been greater emphasis upon physical chemistry; in metallurgy, the introduction of the study of physical chemistry of metals, of X-ray analysis, and considerably elaborated work in metallography, both ferrous and nonferrous. Our engineering courses, including metallurgy, do not require modern languages. They have been inserted into the physical metallurgy curriculum, because of their value in research; and particularly because languages are most essential in graduate study, for which the physical metallurgy course will often be the prelude.

I mention this action of Carnegie, not because we can lay claim to originality or pioneering, (others have been doing it, Harvard, for example) but because a situation has developed which warranted a transition from a logically established policy. It will not be surprising if in the future this new tail wags the dog.

Passing from the realm of the undergraduate, one finds that the present day needs of industry have been responsible for graduate programs in metallurgy in many of our colleges. The intricacies of modern alloys and heat treatments, the activities of research in the industry, have necessitated a training in physico-chemical sciences much beyond that possible in the normal, balanced four-year program. Graduate study, many times continuing to the doctorate, is an integral part of our collegiate instruction in metallurgy. The graduate program is fundamentally one of research; with the research aspect gaining in importance and then practically monopolizing the stage as the work for the doctor's degree becomes crystallized. Naturally, this has a profound influence upon teaching personnel and methods. Course matter is more intricate; it is less of the textbook and more of a literature search type. Laboratory investigations take a major place. The teacher must have the qualifications of a research director. It is preferable that he be an authority in some field, and have a recognized standing in the profession; since there is much inspiration to the student in feeling that discourses bear the stamp of leadership, and that his research is under authoritative direction.

The tax of a graduate program is no less severe upon the college than upon the teaching staff. It costs money, in the apportionment

of the teacher's time per student, in the character of equipment needed, and in the accessory needs of the individual students to carry out the allotted research problems. The reward to the institute will come from the pride in contribution to this advance in education, and in enhanced reputation.

Let us emphasize our general treatise by specific examples.

Individual research conducted by the instructor, naturally has a foothold in our colleges, particularly where the aid of graduate students may be drawn upon. They have pyrometers, microscopes, and heat treatment furnaces of the best type. A large variety of problems on the constitution of alloy series have been investigated in college laboratories with the aid of thermal study and the metallographic microscope. Likewise, we are indebted to college research for much knowledge related to heat treatment influences and the mechanism of transitions. The advantage of this character of investigation is that it lies within the scope of the college laboratory, and necessitates the minimum of test material and costly preparation of samples.

Where research problems are assigned as part of a graduate program, it would appear preferable to have each man's study a part of a major coördinated plan, rather than on scattered and isolated topics.

To carry out a comprehensive test program on the basis of individual effort and the usually meager funds available in departmental appropriations, is generally out of the question, due to the heavy expense of material and labor and in the preparation of test pieces, and the large amount of equipment needed to get results.

Everyone seems to have a finger in the fatigue or creep testing pie. While such individual efforts should not be belittled, one questions the wisdom of an investigation with one or two machines or furnaces. A large volume of results and duplicated series are necessary. The Aluminum Company of America has probably 40 or 50 fatigue machines, and the Standard Oil Company of New Jersey has a somewhat comparable number of creep testing furnaces. College laboratories generally speaking can hardly compete with programs of this kind. However, exploratory work may be done with limited equipment.

Much work may be done in the corrosion field, both ferrous and non-ferrous, particularly in studies of the mechanism of corrosion. We have much to learn of oxygen concentration influences, and of film effects in retardation. The benefits of research of such character are obvious, assuming that we have student participation on phases of a comprehensive problem, and that the results are worthy of publication.

The coöperative research now being conducted on a dual ar-

rangement between the Carnegie Institute of Technology on the one hand, and the Advisory Boards in Metallurgy and in Mining composed of representatives in industry, is an interesting example of coöperative and coördinated investigations. Many problems of importance to industry have been studied with the aid of graduate students, in a manner which would have been comparatively ineffective as individual effort, without the guidance of the committee or the direction of a competent supervisor of a major problem such as Dr. Herty in command of the study of Physical Chemistry of Steel Making. Aside from the support of fellowships in the graduate school, I feel that the association has been a stimulating influence to the teaching staff, the student body, and to the Carnegie Institute of Technology.

In a somewhat parallel vein is the Metals Research Laboratory of the Carnegie Institute of Technology. Its problems are largely independently conceived and executed. However, it has the benefit of advice from the Advisory Board noted above. Its work is following along the lines of fundamental research—the constitution of alloys of iron, manganese and carbon; the atomic process in precipitation from solid solutions; the nature of solid solution.

The laboratory is not a part of the teaching division; however, it is an active participant in the graduate set-up, through graduate fellows and students in its personnel, and because the personnel is contributing special courses of instruction and has a voice in graduate policy. Its value to the Institute, both direct and indirect, cannot be denied.

The University of Pittsburgh has had for years a direct affiliation with the Mellon Institute of Industrial Research. To-day there is no direct tie, since there is no interrelationship between the research staff and the University teaching program. Some of the research workers, as might be expected, are pursuing graduate studies, and some of the Institute lectures on special topics are available to students. Its chief asset value to the University is the prestige and stimulation from close relationship, and the advantage of the Institute as a training ground for research workers in their transition from college halls to industrial research.

Much might be written about research organizations and their influence upon the college. Such institutions as the Battelle Memorial Institute, the Bureau of Mines and the Bureau of Standards, have a material influence of varying degree and character, through contiguity or affiliation, or perhaps only through their personnel requirements reflecting upon the type of instruction to fill the need.

I am a firm believer in group research—that is, group support on projects of common interest. I believe that allotment of such

work to laboratories closely affiliated with our colleges is an advantageous arrangement. Universities which are associated with engineering experiment stations, or have well organized research laboratories in close affiliation, appear to present an ideal base for coöperative effort.

Industrial research has now reached a high plane, both in volume and type of work. When one looks into the activities of the United States Steel Corporation, the Aluminum Company of America, the American Rolling Mill Company, the Westinghouse Electric and Manufacturing Company, the General Electric Company, and a host of others in metals consuming as well as metals producing lines, the conviction is forced home that the teaching program of our colleges is markedly influenced in quality and type by the specifications set by such organizations in recruiting their personnel.

It is my belief that for the general works requirements leading to control or operating positions, the four-year college course, based upon an engineering set-up with a plentiful interweaving of basic metallurgy, is the proper collegiate preparation. Post-collegiate training had better be through an apprenticeship in the plant. But where the need and aim is for the higher realms of metallurgical research, such as is now so manifest in the placing of graduates, there appears to be a real need for modification of our traditional set-up in course, and for a program of advanced instruction extending into post-graduate work even as far as the doctorate.

NEW MEMBERS

BAILEY, FLOYD, Dean, Santa Rosa Junior College, Santa Rosa, Calif. F. O. Rose, H. B. Langille.

BINGHAM, EUGENE C., Professor of Chemistry, Lafayette College, Easton, Pa. E. H. Rockwell, Wm. S. Lohr.

CHINN, HARVE N., Instructor in Civil Engineering, Rose Polytechnic Institute, Terre Haute, Ind. D. B. Prentice, H. C. Gray.

HARTSHORN, WILFRID W., Teacher of Mathematics, Brawley Union High School and Junior College, Brawley, Calif. Edward Taylor, F. L. Bishop.

HORACK, CARL W., Associate in Mechanical Engineering, University of California, Berkeley, Calif. H. B. Langille, R. E. Davis.

IVES, HOWARD C., Lecturer, School of Government, University of Southern California, P. O. Box 288, Temple City, Calif. (Reinstatement). P. S. Biegler, R. M. Fox.

MAXWELL, MAXWELL C., General Superintendent, Yale & Towne Manufacturing Company, Stamford, Conn. C. E. Davies, G. A. Stetson.

ROBB, JAMES M., Head, Dept. of Mathematics and Physics, Taft Union High School and Junior College, Taft, Calif. H. B. Langille, D. M. Wilson.

ROSE, FRANK W., Instructor in Civil Engineering, Taft Junior College, Taft, Calif. F. O. Rose, D. M. Wilson.

SMITH, FINLEY W., Instructor in Electrical Engineering, Lafayette College, Easton, Pa. W. B. Plank, Morland King.

WRAY, ROBERT C., Instructor in Civil Engineering, University of Arkansas, Fayetteville, Ark. W. R. Spencer, W. N. Gladson.

76 new members this year.

MACHINE DESIGN CLEARING HOUSE

By FRANK L. EIDMANN, Chairman

The bulletin distributed in March to the members of the Clearing House contained the announcement of an Advisory Committee appointed by the Chairman to direct the activities of this growing activity of the S. P. E. E. The appointees are: Wm. Howard Clapp, California Institute of Technology; John M. Foster, North Carolina State College; O. A. Leutwiler, University of Illinois; and Edgar MacNaughton, Tufts College.

The bulletin includes the remarks of six authors of machine design text-books who were invited to discuss "The Suitability of Texts on Machine Design." This subject was discussed in the *Journal of Engineering Education* (Dec., 1933, p. 289) by a number of members of the Clearing House.

The December bulletin which was distributed to the members of the Clearing House contained an interesting and stimulating account of the aims, curriculum and results of the School of Mechanical Design which is conducted by the Westinghouse Electric and Manufacturing Company for the training of technical graduates for mechanical design work. More than one hundred students have attended this school. The courses include Engineering Mathematics, Applied Elasticity, Testing Materials, Metallurgy, Ventilation, Lubrication, Dynamics, Vibration, Electro-dynamics, Special Lectures, and Special Problems.

The January bulletin of the Clearing House contained a report of the Machine Design conference held at the annual meeting of the S. P. E. E. in Chicago. The topic presented in the bulletin for discussion by mail was "A Course in the Selection of Engineering Materials," raising the question as to whether a separate course should be given or whether it should be combined with another course. A synopsis of the discussion will be presented later.

The February bulletin consists of a number of typical problems which have been used in his course in Mechanics of Materials by Professor G. B. Karelitz. The topic presented for discussion was "Should Problems Requiring Originality of Design, or Invention, Be Given in a Course in Machine Design?"

Members of the S. P. E. E. may obtain copies of the above bulletins without charge by addressing the chairman of the Clearing House.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

Engineering Drawing Competition.—The engineering drawing exhibition and competition for the 1934 meeting at Cornell will follow the same general specifications as prevailed in 1933. The last competition exhibited fifty some drawings from thirteen institutions. Members of the division are invited and urged to submit drawings as indicated in the specifications which follow.

Teachers of engineering drawing should keep in mind the great value of examining and comparing the best student drawing in the country with the work being done in their own departments. In addition to the value in prestige to the teachers and institutions whose work wins an award, the importance of the exhibitional features of such a competition can not be overemphasized.

Specifications.—Submitted drawings must be regular assignments done by students in a first year drawing class. One drawing only in each class may be submitted. Each drawing must be identified with the name of the institution, of the instructor, of the student, and the competition class in which it is entered. Three places will be awarded in each of the following classes:

Class A. A pencil drawing made with instruments embodying an orthographic shape description only.

Class B. A pencil drawing made with instruments, including both an orthographic shape and size description.

Class C. An inked drawing made with instruments on paper, vellum, or tracing cloth which shall include all the features of a working drawing.

Class D. A freehand pictorial sketch.

Features at June Meeting.—Of special interest this year at the Cornell meeting will be exhibits of old books on drawing and descriptive geometry, of old drawings, and of drawing tools both ancient and modern.

GRADUATE FELLOWSHIPS

The Secretary, on February 12, 1934, sent the following postcard to the dean of every engineering school in the United States and Canada:

We wish to publish in THE JOURNAL OF ENGINEERING EDUCATION, for the convenience of the members of this Society, a list of fellowships that will be open in 1934–35. Will you please send us a statement of the number available classified by departments, stipend of each, and any other information which we should have?

The following information has been secured. A supplemental list will appear as additional information is received. Any member wishing to avail himself of the opportunities presented herewith should communicate at once with the dean of the school concerned.

AKRON, UNIVERSITY OF: 1 fellowship in rubber chemistry, department of chemistry. Stipend, $750.

CARNEGIE INSTITUTE OF TECHNOLOGY: Metallurgical Advisory Board fellowships. Fellows required to register for advanced degree, $750, free tuition. Mining Advisory Board fellowships. Research problems assigned pertain to the study of coal. Fellows required to register for degree of M.S., $500, free tuition. Teaching fellowships in chemistry, physics, and engineering. Fellows required to register advanced degree, $400 and $600, free tuition.

COLORADO, UNIVERSITY OF: 10 research fellowships. Stipend, $400 in addition to tuition and any major department fees.

CORNELL UNIVERSITY: McGraw fellowship, civil engineering, $400 free tuition; Elon Huntington Hooker fellowship in hydraulics, $510, research in experimental hydraulics in Europe or America; Sibley fellowship, $400, free tuition, and Edgar J. Meyer Memorial fellowship, $400 and free tuition, both in mechanical engineering; Charles Bull Earle Memorial fellowship in electrical engineering, $400 and free tuition.

FLORIDA, UNIVERSITY OF: 2 graduate assistants, civil and mechanical engineering, $360.

HARVARD UNIVERSITY: 8 scholarships in all departments of Graduate School of Engineering; 2 scholarships in departments of Mining and Metallurgy (not included in above). Stipend covers approximately the tuition fee.

KANSAS STATE COLLEGE: 2 part-time research assistantships in applied mechanics dept.; 2 in agricultural engineering; 1 in electrical engineering, Engineering Experiment Station; $450 for nine months' service.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY: Full-time assistantships, $1,000 to $1,200; half-time assistantships, $500 to $600; teaching fellowships, $800.

NORTH DAKOTA, UNIVERSITY OF: 1 industrial fellowship (research which will aid in solution of problems connected with development of natural resources (lignite and clay) and industries of the state). Stipend, $500.

OHIO STATE UNIVERSITY: 6 fellowships; 24 scholarships; 1 *Robinson* fellowship; 1 *Nathaniel Wright Lord* fellowship. Stipend of latter two, $750 each.

PENNSYLVANIA STATE COLLEGE: 4 graduate assistants in architecture and engineering; half time given to institution and half time to graduate study; $800. 6 graduate stipend scholars giving small amount of time to institution, $300. 10 graduate scholars.

PENNSYLVANIA, UNIVERSITY OF: Moore School of Electrical Engineering. 4 fellowships. Stipend, $400.

PRINCETON UNIVERSITY: 1 *Orson Desaix Munn* University Fellowship in Electrical Engineering. Stipend, $750.

RENSSELAER POLYTECHNIC INSTITUTE: 5 fellowships—1 in civil, 1 in mechanical, 1 in electrical, and 2 in chemical engineering, $600.

SOUTH DAKOTA STATE SCHOOL OF MINES: 1 fellowship in chemistry, $600.

STEVENS INSTITUTE OF TECHNOLOGY: Henry Morton scholarship, $350.

SYRACUSE UNIVERSITY: Several graduate assistantships, tuition and fees as compensation for services rendered in laboratories and drafting rooms.

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS: 23 graduate assistants and graduate fellows. Stipend, $405.

VIRGINIA POLYTECHNIC INSTITUTE: 3 fellowships in chemistry and chemical engineering, $600 each; 3 fellowships in engineering, $600 each; 6 fellowships in fuel and power engineering, $600 each; 9 fellowships, graduate and teaching, $400; free tuition and no fees.

VERMONT, UNIVERSITY: 7 fellowships in research or profession of teaching, $700, free tuition; 10 scholarships, $300.

WASHINGTON, UNIVERSITY OF: 4 research fellowships in mines, $720 each for 12 months beginning July 1; 3 Loretta Denny fellow-

ships, $500, any department of University; 1 Dupont fellowship, $750, in chemistry or chemical engineering.

WASHINGTON UNIVERSITY (St. Louis): Graduate assistantships. Stipend, $375 to $750.

WISCONSIN, UNIVERSITY OF: 3 fellowships. Stipend, $600. 1 research graduate fellowship, appointment for two years, stipend, $750, first year, $900, second year.

COLLEGE NOTES

Polytechnic Institute of Brooklyn announces the offering of a new curriculum, entitled Liberal-Science, for students entering in February, 1934, and thereafter. This curriculum is offered in addition to the regular curricula in engineering and in chemistry which the Institute provides. It is intended to meet the needs and desires of those students who wish to pursue a broad education in the fundamentals of science or technology that will offer opportunity for the selection of a particular field of interest and will at the same time provide the broad basis of preparation needed for a career in the modern social organization, based as it is in large measure upon scientific discovery, technological development, and economic application.

The curriculum is organized in accordance with the same principles as are applied in engineering curricula in that it requires definite sequences of subjects of instruction extending throughout the four undergraduate years. It provides, however, greater freedom of choice among subjects to be pursued. The first two years are prescribed. During that period the student will be under close supervision and will follow a program of study following rather closely the first two years in engineering, except that no engineering subjects will be required. The last two years are essentially elective. The student will be required to elect major and minor groups of subjects in fields of concentration, thus focusing his work on specific educational objectives and retaining the merits of sequential and purposeful effort. Group options are provided in five fields: Administration, Applied Mechanics, Chemistry, Mathematics, and Physics. Recommended groups of subjects are available in each of these fields, comprising from 25 to 34 semester-hours of work, and extending throughout the four years. In addition, minimum requirements are prescribed in English, modern foreign languages, social sciences, and physical education. The total requirement for graduation is 136 semester-hours. Entrance requirements are the same as in other curricula provided by the Institute. A basic feature of the plan is provision, under guidance by faculty advisers, for students to offer substitutions for courses listed in the required groups, except as to the so-called liberal courses.

It is the avowed purpose of Polytechnic Institute of Brooklyn, in providing the new curriculum, to offer opportunity for students

to pursue a liberal scientific education within the environment of purposeful study prevailing in a college of engineering.

Northeastern University has recently acquired 117,715 square feet of land from the Durant, Inc. This land adjoins the present University holdings on Huntington Avenue in the Back Bay Section of Boston. This brings the total land holdings of the University, exclusive of the Huntington Athletic Field, up to 253,409 square feet. The area includes, in addition to the land just acquired, the tennis courts adjacent to the Main Building, the rear land now used for a parking area, and the land upon which the Laboratory Building of the University stands. In addition, the University owns the Huntington Field totaling 193,500 square feet in area.

The acquisition of this land from Durant, Inc., gives the University a total frontage on Huntington Avenue of 456 feet. This land furnishes an admirable site for an urban institution and will enable Northeastern to proceed with the development of plans for its future buildings.

The University will, without delay, secure the services of an architect for laying out the several buildings necessary to a complete University plant development. These buildings will be arranged in the order of importance, and the plan will be so developed that building units may be undertaken in that order as funds are secured for construction. The immediate objective of the University will be the construction of a Recitation Building to replace the leased areas now occupied in the Huntington Building and an Engineering Building which, of course, will be additional to the present facilities and which will provide adequate engineering laboratories.

It is confidently expected that the University will be able to develop its new site within a reasonable space of time. In the end the plan calls for a plant development which will be thoroughly utilitarian and yet be architecturally well balanced.

The Boston Chapter, American Society of Industrial Engineers, has organized a Motion Study Section, and will hold instructional meetings twice a month during the winter at Northeastern University. Representatives of Boston's leading industries are taking part in the study course, which began in January.

The chief topic of study will be the "Gilbreth Technique." The appeal of this sort of thing to members of the engineering profession is that they feel that operators have been too long neglected, and something should be done to overcome both fatigue and the resulting loss of time and money caused by it.

The introductory lecture of the course was delivered by Professor James W. Ingalls, head of the Industrial Engineering Department at Northeastern. Other papers will be read by Herbert T. Smith, instructor at M. I. T., and by Archie Williams of the Hood Rubber Company. Mr. Smith will lecture on "Process Chart, Their Construction and Use," and Mr. Williams' subject will be "The Technique of Micro-Motion Study." As the course progresses, motion pictures of actual processes will be made in factories for the purpose of analysis by the group.

SECTIONS AND BRANCHES

The **Lafayette Branch** of the S. P. E. E. was organized on January 4, 1934, with the following officers:

Chairman—Morland King
Vice-Chairman—W. S. Lohr
Secretary-Treasurer—E. H. Rockwell.

The Branch adopted the following Constitution and By-Laws:

CONSTITUTION

Article 1

Name and Purpose

Section 1. The name of this organization shall be the Lafayette College Branch of the Society for the Promotion of Engineering Education.

Section 2. The purposes of this Branch shall be identical with those of the Society for the Promotion of Engineering Education, and more specifically to study the problems connected with engineering education at Lafayette College.

Article 2

Membership

Section 1. Membership in the Branch shall be of two classes, Active and Affiliate. Active Members shall be members of the Society for the Promotion of Engineering Education. Affiliate Members shall be others who are interested in the purpose of this organization. Affiliate members shall not be eligible to hold office, or vote at elections.

Article 3

Dues

Section 1. The Branch shall have no fixed dues. It shall be financed by contributions solicited by the Secretary-Treasurer as the need may arise.

Article 4

Officers

Section 1. The officers shall be a Chairman, a Vice-Chairman, and a Secretary-Treasurer, each to serve one year.

Article 5

Meetings

Section 1. Regular meetings shall be held the last Thursday in September, October, November, January, February, March and April.

Section 2. Special meetings shall be called by the Chairman when deemed necessary by the officers or when requested in writing by five active members.

Section 3. A quorum shall consist of a majority of the active members.

ARTICLE 6

Amendments

Section 1. This Constitution may be amended at any regular meeting by a majority vote of the Active Members, provided that all members have been notified in writing by the Secretary-Treasurer of the proposed amendment at least two weeks prior to the date of the meeting.

BY-LAWS

Section 1. The Chairman shall be ex-officio a member of all Committees.

Section 2. The officers of the Branch shall constitute the Program Committee.

Section 3. The concluding business at the April meeting shall be the election of officers for the ensuing year, except that for the first year officers shall be elected at the organization meeting.

Section 4. By-laws may be amended by a majority vote of the active members present at any regular meeting.

At a meeting, held on February 22, 1934, the **Lafayette College Branch** voted to approve the first annual report of the Engineering Council for Professional Development, in regard to the accrediting of engineering schools, and that a copy of this action be transmitted to the Secretary of the Society for the Promotion of Engineering Education.

The second meeting of the **Minnesota Section** of the Society for the year 1933–34 was held at the Minnesota Union, Monday, March 5, 1934. There were about thirty-five present at the meeting which was preceded by dinner served at 5:45 P.M.

The principal speaker of the evening was Dr. John T. Tate, Chairman of the Science Group Committee of the Graduate School at the University, who addressed the Section on "Graduate Study and Research in Engineering." In the absence of President E. W. Johnson, Lorenz G. Straub presided.

The minutes of the preceding meeting were read by Dr. R. E. Montonna and approved.

Dr. Tate discussed the rapid increase in graduate work in engineering at the University of Minnesota during the past few years He indicated that some industries preferred to train their own men in advanced technical work rather than rely upon graduate work at universities. He asked two specific questions which he left open

for the faculty to answer for themselves, namely, (1) Is the undergraduate curriculum suitable for preparing the student for graduate work? (2) Are the faculties properly staffed?

Dr. Tate indicated his belief that students in undergraduate work who intend to continue for masters' and doctors' degrees should be given more work in the basic sciences such as mathematics, physics, and chemistry, also a reading knowledge of German. He believes that graduate work in engineering should serve to bridge the gap between industry and the fundamental sciences required in the industry. The engineering students trained in the graduate school should be capable of applying the new facts of science to the development of industry.

After considerable discussion by various members of the Society, it was suggested that the interest expressed be crystallized by definite steps toward a systematic development of graduate work in the College of Engineering at the University, possibly by the appointment of a committee on graduate work.

The second annual meeting of the **Pacific Southwest Section** was held in Los Angeles, at the University of Southern California, on December 28th, 29th and 30th. The Chairman of the Section, Professor H. B. Langille, University of California, presided.

The afternoon of the second day, visits were made to the moving picture studios and laboratories. An informal reception and dinner was held at the Women's Residence Hall of the University that evening, at which Dr. Edwin Diller Starbuck, of the Department of Philosophy of the University of Southern California, told in a most fascinating manner of the relation of æsthetics to mathematics and engineering.

The Executive Committee accepted the cordial invitation of Dean Derleth, of the College of Engineering of the University of California, to hold the third annual meeting of the Section at Berkeley in December, 1934.

The following officers were elected for the calendar year 1934:

Chairman	D. M. Wilson, University of Southern California.
Vice-Chairman	Arthur B. Domonoske, Stanford University.
Secretary-Treasurer	Franklin O. Rose, Modesto Junior College.
Executive Committee	Arthur G. Gehrig, Pasadena Junior College.
	H. R. Kepner, Utah State Agricultural College.
	H. B. Langille, University of California.
	F. H. Sibley, University of Nevada.

The following members of the Section were present:

P. S. Biegler, University of Southern California
H. H. Bliss, Riverside Junior College
C. E. Cherry, Marin Junior College
F. H. Cherry, University of California
R. E. Davis, University of California
John F. Dodge, University of Southern California
Arthur B. Domonoske, Stanford University
Gilbert H. Dunstan, University of Southern California
T. T. Eyre, University of Southern California
R. M. Fox, University of Southern California
Arthur G. Gehrig, Pasadena Junior College
V. C. George, Long Beach Junior College
C. E. Guse, Los Angeles Junior College
John W. Hazen, Los Angeles Junior College
H. R. Kepner, Utah State Agricultural College
H. B. Langille, University of California
E. J. Mayer, New Mexico Normal University
Geo. B. Miller, Cogswell Polytechnic Institute
John C. Park, University of Arizona
Donal B. Pheley, Los Angeles Junior College
K. W. Rich, Kern County Junior College
Franklin O. Rose, Modesto Junior College
F. H. Sibley, University of Nevada
Arthur C. Terrill, Fullerton Junior College
H. B. Walker, University of California
R. H. Walters, Los Angeles Junior College
Daniel E. Whelan, Jr., Loyola University
D. M. Wilson, University of Southern California
B. M. Woods, University of California.

Professor Geo. J. Hood, of the University of Kansas, and Dean R. G. Tyler, of the University of Washington, were visitors at the meeting.

The following visitors at the meeting filed their applications for membership in the Society:

C. H. Haentjens, Santa Rosa Junior College
C. W. Horack, University of California
J. M. Robb, Taft Junior College.
F. W. Rose, Taft Junior College.

The following non-members of the Society were welcomed as visitors at the meeting:

G. W. Duncan, Los Angeles Junior College
S. F. Duncan, University of Southern California
Edward B. Heath
F. C. Lindvall, California Institute of Technology

S. S. Mackeown, California Institute of Technology
Chas. H. Paxton, University of California at Los Angeles
E. E. Reese (Miss), Polytechnic Evening High School, Los Angeles
M. J. Smith, Los Angeles Junior College
Edward C. Snyder, Citrus Junior College
A. B. Stevens, University of Southern California
R. B. Vaile, Jr., California Institute of Technology
H. J. Winslow, United States Naval Academy.

FRANKLIN O. ROSE,
Secretary-Treasurer.

The Pennsylvania State College Branch of the Society held a reorganization meeting on Wednesday evening, December 13, 1933, at 7 o'clock. Twenty members and guests were present.

Professor C. L. Harris, Vice-President, presided and opened the meeting with some introductory remarks concerning the reorganization of the branch.

Mr. A. P. Powell, Secretary, then read the minutes of the last meeting, March 7, 1928, which were approved as read.

The reorganization of the branch next took place. After a brief discussion the report of the committee appointed to recommend candidates for the various offices in the branch, was read by its chairman, Professor C. E. Bullinger. The committee suggested the following names for officers:

President: Professor L. S. Rhodes
Vice-President: Mr. A. E. Neyhart
Secretary-Treasurer: A. P. Powell.

The report of the committee was unanimously accepted.

Dean Sackett then gave a very interesting talk concerning the Engineers' Council for Professional Development. He stated that this Council was the outgrowth of the work of a committee of the A. S. M. E., and whose object was the determination of the economic status of the engineer. The Council now has the support and co-operation of seven national engineering organizations, among them the S. P. E. E. The Council is functioning under four committees: 1. Student Selection and Guidance (R. L. Sackett, Chairman); 2. Engineering Schools; 3. Professional Training; and 4. Professional Recognition.

Professor L. S. Rhodes and Dean R. L. Sackett both spoke of the coming annual convention of the S. P. E. E. to be held at Cornell this June and stressed that it would be a young man's convention for the first few days of the convention.

The Chicago Conventions of June, 1933, were the final topics Professor Rhodes spoke on the S. P. E. E. convention and Pro-

fessor Harris on the General Engineering Conference. Professor Rhodes spoke of the atmosphere of the convention: Chicago, the World's Fair, the many societies meeting, the addresses, the discussion groups, the meeting of friends, etc. In discussing the General Engineering Conference Professor Harris spoke particularly concerning a paper ably presented by a young man; and of his interest in the design of a steel column.

The meeting adjourned at 7:45 P.M.

Respectfully submitted,

ALBERT P. POWELL,
Secretary.

The meeting of the **Texas Section** of the S. P. E. E. will be held in Houston, Texas, at Rice Institute on April 19 and 20, 1934. A cordial invitation is hereby extended to W. E. Wickenden, National President of the S. P. E. E., F. L. Bishop, National Secretary, and W. O. Wiley, National Treasurer, and all Presidents of other State Sections to meet with us. We expect to put the little pot in the big one and have "pot likker," sweet "taters," corn bread, turnips and butter milk on our menu.

T. U. TAYLOR,
President.

The annual meeting of the Ohio Section will be held April 14 at The Ohio State University. At the morning meeting President Wickenden will speak on "Recovery Program for Schools of Engineering," and at the afternoon meeting B. L. Stradley, Entrance Examiner at the University, will speak on "The Selection of Engineering Students."

SAMUEL B. FOLK, *Acting Secretary.*

BOOK REVIEWS

Differential Equations. By NELSON BUSH CONKWRIGHT, Associate in Mathematics, University of Iowa. Published by Macmillan Co. 1934. 234 pages.

Professor Nelson Bush Conkwright has written a serviceable book for a first course in differential equations. The exercises are well chosen and well arranged. Chapter III has a nicely selected set of problems showing applications of differential equations to other sciences. The approach to the subject of singular solutions is very well made. The important ideas in the subject of numerical approximations are plainly presented. The topics in partial differential equations are well written. The inclusion in the Appendix of the standard integrals and other helpful suggestions to the student is a useful innovation.

M. M. CULVER.

Cost and Production Handbook. L. P. ALFORD, Editor. 1544 pages. Ronald Press Company, 15 East 26th St., New York City, N. Y., 1934. $7.50.

Few men in the country are in a better position to review, summarize, evaluate, and edit latest developments in the field of management technique than Dr. Alford. In the present monumental task, he has been assisted by a board of eighty specialists in cost accounting, manufacturing, and engineering. The result is a highly authoritative volume which will be of great value to industrial executives and engineers.

Since the enunciation by Frederick W. Taylor of the principles of management, there has been an evolution of technique along many lines. Industrial organization and management, time and motion study, production planning and control, labor control, and standard costs have all had intensive and expert treatment. Relatively few attempts have been made to co-ordinate such specialized treatises into a single related volume. Management's Handbook (Ronald Press Company, 1923) was such an attempt and for a time served a widely-felt need. Even it, however, in the light of more recent developments, has been shown to be a transitional treatment. The present volume is, as the editor states, both a narrower and a broader treatment than Management's Handbook. It is narrower in that it deals primarily with production. It is

broader in that it codifies practically all of the now-known mechanisms of production management.

In still another sense is the present volume a noteworthy contribution to management literature. It reduces to simple working formulas or "principles" many of the complex relationships involving the elusive personal equation. It is relatively easy to reduce to a working formula many physical, chemical or mathematical relationships. When the result involves the behavior of human workers, the formula becomes exceedingly complex. In such cases, the editors have, by observation of a large number of cases and by trial-and-error treatment, evolved certain working principles or laws. These are presented in clear and logical fashion throughout the twenty-eight sections of the book.

Naturally there are omissions in context which some authorities will feel constitute a weakness. Nevertheless, the book presents the cream of the best thinking and writing on all subjects. Excellent cross references permit following up certain detailed treatment. Finally, an excellent index, covering forty-six pages, permits quick reference to a desired topic.

A thorough and adequate review of a volume of this type requires a complete statement of the contents. Space does not permit such an analysis here. It is sufficient to say that there is a commendable unity of purpose back of each section—utility. There is also a striking correlation of all topics—cost accounting methods, production and expense budgets, factory organization, statements, reports, production planning and control, standard cost methods, job and methods standardization, rate setting, cost analysis, purchasing, research, incentive plans, and a host of related topics.

It is apparent from its very nature that the book is intended as a handbook and guide for industrial executives. No mention is made of its use as a guide for students in accounting, management, and industrial engineering courses. It is admirably adapted to this latter use.

JOHN W. HALLOCK.